

FIG. 1A. The LED 100 is a standard sandwich heterostructure comprising several n and p type semiconductor layers. It includes an n-type gallium arsenide, GaAs, substrate 101 disposed on a metallic conductor 102. An n-type doped layer 103 of gallium aluminum arsenide, GaAlAs, is disposed on the substrate 101. Disposed on layer 103 is the active p-type gallium arsenide layer 104. A p-type gallium aluminum arsenide, GaAlAs layer 105 is disposed on layer 104 and a p-sup.+ -type gallium arsenide layer 106 is disposed on layer 105. Metallic conductors 107-1 and 107-2 are disposed on layer 106 forming a narrow groove therebetween. Conductors 107-1 and 107-2 are electrically connected together and, when a voltage is impressed between conductors 107-1 and 107-2, and conductor 102, light is emitted from the planar surface area 108 between conductors 107-1 and 107-2.

(3) In accordance with the present invention, light coupling between the light-emitting diode 100 and an optical fiber waveguide 110 is effected by laterally affixing the terminating portion of the optical fiber waveguide 110 on the emitting area 108 of the diode so that the axis of the terminating portion is substantially parallel to the plane of the emitting area 108. The cladding on the terminating portion of the optical fiber waveguide 110 is removed by any number of well-known methods and the end of the optical fiber waveguide is polished to form a bevel 111. As can be noted in FIG. 1B, the beveled fiber end 111 makes an angle  $\theta$  with emitting area 108. The light rays that emerge from emitting area 108 at an acute angle are coupled directly into the optical fiber waveguide all along the area of contact between the emitting area 108 and the waveguide 110. In addition, the polished beveled fiber end forms a reflector. Thus, the rays that emerge from emitting area 108 from the region under the bevel that are not directly coupled into the fiber, are reflected into the fiber waveguide by bevel 111. In a preferred embodiment, the bevel 111 is coated with a reflective material 112, such as aluminum. In addition, the entire terminating portion of the optical fiber waveguide can be coated with the same reflective material to optically isolate the light coupled into the waveguide. If the terminating portion of the optical fiber is coated with a reflective material, the coating is removed from the circumferential area that is placed in contact with the emitting surface 108. In order to permanently affix optical fiber waveguide 110 to the LED 100, the fiber is bonded to conductor 107 with a material which has a refractive index the same as or greater than the refractive index of the fiber core, such as an epoxy. FIG. 1C shows the epoxy material 113 in contact with the fiber 110 and the conductor 107.

(4) FIGS. 2A, 2B and 2C show a second embodiment of the present invention in which light power is laterally coupled from a Burrus-type light-emitting diode 200 into an optical fiber waveguide 201. FIGS. 2B and 2C are cross-sectional views of FIG. 2A. Rather than etching a circular "well" through the upper semiconductor gallium arsenide layer to the light-emitting surface thereunder, as in the typical Burrus diode, a groove is etched through an n-type gallium arsenide layer 202 to the light-emitting n-type gallium aluminum arsenide

Patent Dec. 19, 1978

Sheet 2 of 4

4,130,343

